iv. Transverse Damper/Tune Measurement System

This system consists of a beam position monitor, signal processing electronics, a wideband amplifier, and a transverse kicker device in each of the horizontal and vertical planes. The system will be used to control injection errors, to excite coherent betatron oscillations in order to measure the tune, and to suppress coherent transverse instabilities.

The beam position monitors will be located in an insertion region with low dispersion separated from the kicker by a quarter betatron wavelength. The kicker will employ striplines which produce both electric and magnetic deflection and can support the wide system bandwidth required to operate on each bunch individually (including the optional case of 2×60 bunches). Wideband power amplifiers (10 kHz to 100 MHz) will be used to provide the peak deflections required to cope with the expected injection errors and the gain required to control the growth of coherent instabilities. A wider bandwidth will be provided if intrabunch modes must be damped.

The system's power requirements are driven by the damping rate needed to recover from these injection errors. In order to estimate the power required, the following case is considered. The maximum allowed injection errors will lead to betatron oscillations with an amplitude of 2 mm. To avoid emittance dilution of the beam, a damping time equivalent to 100 revolutions is required. In order to decrease the damping time for injection errors, the gain will be programmed so that the maximum kick is applied every turn as long as the oscillation amplitude is above some pre-determined value. Once the minimum amplitude is reached, an amplitude dependent damping program is reinstated in order to suppress any potential instability. The angular kick per turn needed to provide the above damping time is $\Theta = 0.4$ µrad per turn.

For relativistic ions, the angular deflection per turn Θ is given by the following expression where equal contributions from electric and magnetic fields are assumed and a transit time factor is neglected

$$\Theta = \frac{4Ze}{Am_0 c^2 \gamma d} V\ell$$

where Z is the charge state, e is the charge of an electron, A is the atomic mass, m_0 is the specific mass of a nucleon at rest, c is the speed of light, γ is the relativistic mass factor, d is aperture of the stripline pair, l is the stripline length, and V is the voltage of a stripline relative to the beam pipe.

The most demanding requirements are set by the injection errors of gold ions: $Z = 79$, $A = 197$ and $\gamma m_0 c^2 = 10.8$ GeV/u. For a $\ell = 2$ m long kicker with $d = 8$ cm aperture, the voltage requirement is $V = 200$ V. Assuming a stripline characteristic impedance of $R = 50\ \Omega$, the total power requirement per plane is given by

$$P = 2V^2/R \approx 400 \text{ W}.$$